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DIAGNOSTIC ACCURACY OF ULTRASOUND IN DIAGNOSING ECTOPIC PREGNANCY IN A TERTIARY CARE HOSPITAL

Original Research

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ABSTRACT

Background: Ectopic pregnancy is a leading cause of maternal morbidity and mortality in early gestation, necessitating timely and accurate diagnosis to avert adverse outcomes. Ultrasonography, particularly transvaginal sonography, has emerged as a pivotal diagnostic tool due to its non-invasive nature and accessibility. Despite its widespread use, variability in diagnostic precision, especially specificity, remains a concern, highlighting the need for continuous evaluation against definitive surgical findings to enhance clinical decision-making and reduce unnecessary interventions.

Objective: To determine the diagnostic accuracy of ultrasound in diagnosing ectopic pregnancy, using surgical findings as the gold standard.

Methods: This descriptive cross-sectional study was conducted at the Jinnah Postgraduate Medical Centre (JPMC), Karachi. Women aged 18–40 years presenting with clinical suspicion of ectopic pregnancy, based on signs, symptoms, and β-hCG levels above 5 IU/L, were enrolled using non-probability consecutive sampling. Transvaginal ultrasound examinations were performed by experienced radiologists, and findings were compared with surgical outcomes. Data were analyzed using SPSS version 26.0. Sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and diagnostic accuracy were calculated along with 95% confidence intervals.

Results: A total of 240 participants were included, with a mean age of 29.29 ± 5.84 years; 60% were aged 18–30 years, while 40% were above 30 years. Ultrasound accurately identified 220 cases of ectopic pregnancy. Sensitivity was 97.77% (95.85%–99.70%), specificity was 60.0% (35.21%–84.79%), PPV was 97.35%, and NPV was 64.29%. The overall diagnostic accuracy was 95.42%. Positive and negative likelihood ratios were 2.44 and 0.04, respectively.

Conclusion: Ultrasound demonstrated high sensitivity and diagnostic accuracy in detecting ectopic pregnancy when compared to surgical findings. Despite moderate specificity, ultrasound remains a vital, non-invasive tool for early diagnosis, although additional confirmatory strategies may be required to minimize false positives and optimize patient management.

Keywords: Diagnostic Imaging, Ectopic Pregnancy, Pregnancy Diagnosis, Sensitivity and Specificity, Surgical Findings, Ultrasonography, Vaginal Ultrasound.

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INTRODUCTION

Ectopic pregnancy, a condition in which the blastocyst implants outside the uterine endometrium, remains a significant clinical challenge due to its varied presentations and potential for life-threatening complications. It accounts for approximately 1.9% of all pregnancies globally (1), with regional prevalence rates reported around 1.4% (2). Often termed "the great masquerader," ectopic pregnancy can manifest with a wide spectrum of symptoms, ranging from complete asymptomatic states to severe outcomes like hemoperitoneum and circulatory shock (3). Alarmingly, up to 70% of patients present with atypical or nonspecific symptoms, making timely diagnosis a substantial hurdle for clinicians (4). Although the classic triad of amenorrhea, abdominal pain, and vaginal bleeding is traditionally associated with ectopic pregnancy, it is observed in only half of the affected individuals (5), underscoring the need for a vigilant and proactive diagnostic approach. The early and accurate identification of ectopic pregnancies is crucial to minimize maternal morbidity and preserve fertility potential. The absence of an intrauterine pregnancy on transvaginal sonography (TVS) coupled with a serum β-hCG concentration exceeding 1500 IU/L serves as a critical marker in diagnosing ectopic pregnancies (6,7). The combination of β-hCG measurements with high-resolution TVS has markedly improved early detection rates (8), while advancements like color flow Doppler technology have further enhanced diagnostic accuracy (9). Given its ability to provide detailed visualization of pelvic anatomy, ultrasonography has become an indispensable tool, allowing sonologists to play a pivotal role in evaluating suspected cases (10). Ultrasonographic detection of an intrauterine gestational sac can occur as early as five weeks of amenorrhea (11), facilitating early interventions that are vital for safeguarding maternal health and reproductive outcomes (10,11).

Unlike any other imaging modality, ultrasonography has demonstrated superior efficacy in detecting both ectopic and heterotopic pregnancies during the earliest stages (12). Furthermore, it assists in distinguishing ectopic pregnancy from other gynecological and surgical conditions, including impending abortion, ovarian torsion, and appendicitis. For hemodynamically stable women, TVS remains the primary investigative modality, boasting diagnostic accuracy rates approaching 90% (13). A study reported a prevalence rate of 0.88% for ectopic pregnancy in a given population, with ultrasonography yielding a remarkable sensitivity of 99.52% but a relatively low specificity of 11.11%, and an overall diagnostic accuracy of 95.83% (14). Similarly, a study found ultrasound to have a sensitivity of 73.1%, specificity of 75%, and a diagnostic accuracy of 73.3% in detecting ectopic pregnancies (15). Existing literature consistently affirms the high sensitivity of ultrasonography in diagnosing ectopic pregnancy, particularly in complicated cases involving rupture and hemoperitoneum (16,17). Despite these advances, challenges remain in achieving consistently high diagnostic accuracy, particularly in early and atypical cases. There is a compelling need to further refine ultrasound techniques to improve diagnostic precision, reduce unnecessary surgical interventions, and ultimately lower the incidence of maternal morbidity and mortality associated with ectopic pregnancies. Therefore, the objective of this study is to enhance the diagnostic accuracy of ultrasound in detecting ectopic pregnancy, contributing to earlier intervention, preservation of fertility, and improved reproductive health outcomes for women.

METHODS

This descriptive cross-sectional study was conducted at the Department of Obstetrics and Gynecology, Jinnah Postgraduate Medical Centre (JPMC), Karachi, with the aim of evaluating the diagnostic accuracy of ultrasound in detecting ectopic pregnancy, using surgical findings as the gold standard. Ethical approval was obtained from the Institutional Review Board (IRB) of JPMC prior to commencement, and written informed consent was obtained from all participants. A non-probability consecutive sampling technique was employed for patient recruitment. Women aged 18 to 40 years presenting with clinical suspicion of ectopic pregnancy were considered eligible for inclusion. The criteria for suspicion included one or more of the following: lower abdominal pain with a Visual Analog Scale (VAS) score greater than 3, clinically observed pallor, shoulder tip pain exacerbated by lying down or deep breathing, heavy cramping (VAS ≥3), dyspareunia (VAS ≥3), weakness significant enough to impair movement, nausea lasting one hour or more (with or without vomiting), or fatigue persisting for at least 24 hours despite rest. Additionally, the presence of cervical motion tenderness on pelvic bimanual examination and a β-hCG level greater than 5 IU/L were deemed positive indicators. Only those with a confirmed gestational age between 6 to 12 weeks on ultrasound and β-hCG levels exceeding 5 IU/L were included. Exclusion criteria encompassed women with a confirmed intrauterine pregnancy on ultrasound, the presence of adnexal masses with negative β-hCG levels, those opting for conservative management, or those declining transvaginal sonography (TVS). Patients who were hemodynamically unstable and

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required immediate surgical intervention, those with a history of pelvic surgery or severe pelvic inflammatory disease (PID), those who had undergone recent assisted reproductive procedures such as in vitro fertilization, individuals receiving anticoagulant therapy, patients with contraindications to surgery, and those unwilling to provide informed consent were also excluded to maintain data integrity.

Eligible participants were screened in both emergency and outpatient settings. Baseline demographic and clinical parameters including age, parity, gestational age, height, weight, and body mass index (BMI) were recorded systematically using a predesigned structured proforma. All enrolled women underwent ultrasound imaging performed by a senior radiologist possessing a minimum of five years of post-fellowship experience. Ultrasound findings suggestive of ectopic pregnancy were defined as the presence of any one of the following: an empty uterine cavity without an intrauterine gestational sac, a live extrauterine embryo with cardiac activity, a complex or solid adnexal mass, hematosalpinx, free pelvic or peritoneal fluid, an extrauterine gestational sac containing a fetal pole and/or yolk sac, or a complex adnexal mass associated with free abdominal fluid. Subsequently, all patients underwent surgical exploration performed by a senior gynecologist with at least five years of surgical experience. The intraoperative diagnosis of ectopic pregnancy was confirmed by the identification of an empty uterus accompanied by an extrauterine gestational sac or embryo, with or without the presence of free fluid within the peritoneal cavity. Ultrasound results were then compared against surgical findings to determine the diagnostic accuracy of ultrasound in the detection of ectopic pregnancy. All data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS) software, version 26.0. Descriptive statistics, including means and standard deviations for quantitative variables, and frequencies and percentages for qualitative variables, were computed. Diagnostic performance metrics, specifically sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV), were calculated, taking surgical findings as the gold standard to assess the accuracy of ultrasound.

RESULTS

The mean age of the study participants was 29.29 years, with a standard deviation of 5.84 years. A majority of the participants, 60.0%, were aged between 18 and 30 years, while 40.0% were older than 30 years. The mean Body Mass Index (BMI) recorded was 25.89 ± 3.61 kg/m². Most participants, 62.9%, had a BMI between 25 and 26 kg/m², whereas 37.1% had a BMI greater than 26 kg/m². The mean gestational age among participants was 7.33 ± 0.83 weeks, with 64.6% between 6 and 7 weeks of gestation and 35.4% having a gestational age beyond 7 weeks. Regarding family history, 31.3% reported a positive family history of ectopic pregnancy, while 68.7% did not. Parity distribution revealed that 15.4% of women were nulliparous, 8.3% had parity I, 36.2% had parity II, 28.9% had parity III, and 11.2% had parity IV. Symptomatically, pain was reported by 90.4% of the participants, while 9.6% experienced per vaginal (PV) bleeding at presentation. In comparing ultrasound findings to surgical findings, ultrasound correctly identified ectopic pregnancy in 220 participants, demonstrating a substantial true positive rate. Six participants were falsely categorized as positive by ultrasound but were later found negative on surgical evaluation, representing the false positive group. Five participants were falsely categorized as negative on ultrasound but were diagnosed with ectopic pregnancy during surgery, indicating false negatives. Nine participants were accurately categorized as negative for ectopic pregnancy by both ultrasound and surgical findings. The diagnostic performance of ultrasound demonstrated a sensitivity of 97.77% with a 95% confidence interval of 95.85% to 99.70%, illustrating its robust ability to detect ectopic pregnancy when present. Specificity was calculated at 60.0% with a 95% confidence interval ranging from 35.21% to 84.79%, suggesting moderate performance in identifying true negative cases. The Positive Predictive Value (PPV) was found to be 97.35%, with a confidence interval of 95.25% to 99.44%, indicating a high probability of ectopic pregnancy when ultrasound was positive. The Negative Predictive Value (NPV) was 64.29%, with a confidence interval of 39.19% to 89.39%, reflecting variability in ruling out ectopic pregnancy when ultrasound findings were negative. The overall diagnostic accuracy was recorded as 95.42%, with a confidence interval between 92.77% and 98.06%.

In terms of likelihood ratios, the Positive Likelihood Ratio (LR+) was 2.44, suggesting that a positive ultrasound moderately increased the likelihood of having an ectopic pregnancy. The Negative Likelihood Ratio (LR-) was 0.04, indicating that a negative ultrasound markedly reduced the probability of the condition being present. Further stratification analysis was performed to evaluate the diagnostic accuracy of ultrasound according to gestational age and BMI categories. Among participants with a gestational age of 6–7 weeks, the sensitivity of ultrasound was 98.55%, specificity was 57.14%, positive predictive value (PPV) was 97.19%, and negative predictive value (NPV) was 66.67%. For those beyond 7 weeks of gestation, the sensitivity slightly decreased to 96.36%, specificity improved to 66.67%, PPV was 97.59%, and NPV was 57.14%. In terms of BMI, women with a BMI between 25–26 kg/m² demonstrated a sensitivity of 98.53%, specificity of 66.67%, PPV of 97.85%, and NPV of 75.0%. Conversely, those with a BMI greater than 26 kg/m² had a sensitivity of 96.43%, specificity of 50.0%, PPV of 96.43%, and NPV of 46.15%. These findings suggest that while ultrasound maintains

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high sensitivity across all subgroups, specificity and NPV varied with gestational age and BMI, indicating that diagnostic accuracy could be slightly affected in women with higher BMI or more advanced gestational age.

Table 1: Demographic Characteristics of Study Participants (n=240)

Variable	n (%)
Age (Mean ± SD) = 29.29 ± 5.84	
18-30 years	144 (60.0)
>30 years	96 (40.0)
Body Mass Index (Mean ± SD) = 25.89 ± 3.61	
25-26 kg/m^2	151 (62.9)
>26 kg/m^2	89 (37.1)
Gestational Age (Mean ± SD) = 7.33 ± 0.83	
6-7 weeks	155 (64.6)
>7 weeks	85 (35.4)
Family History	
Positive	75 (31.3)
Negative	165 (68.7)
Parity	
Nulliparous	37 (15.4)
I	20 (8.3)
II	87 (36.2)
III	69 (28.9)
IV	27 (11.2)
Sign/Symptoms	
Pain	217 (90.4)
PV bleeding	23 (9.6)

Table 2: Comparison of Ultrasound and Surgical Findings in Ectopic Pregnancy (n=240)

Ultrasound Findings	Surgical Findings	
	Positive	Negative
Positive	220 (97.8)	6 (40.0)
Negative	5 (2.2)	9 (60.0)

Table 3: Diagnostic Accuracy of Ultrasound in Diagnosing Ectopic Pregnancy (n=240)

Diagnostic Variables	Ultrasound	95% Confidence Interval
Sensitivity	97.77%	0.9585-------0.9970
Specificity	60.0%	0.3521-------0.8479

Diagnostic Variables	Ultrasound	95% Confidence Interval
Positive Predictive Value	97.35%	0.9525-------0.9944
Negative Predictive Value	64.29%	0.3919-------0.8939
Diagnostic Accuracy	95.42%	0.9277-------0.9806
Positive Likelihood Ratio (LR+)	2.44	N/A
Positive Likelihood Ratio (LR-)	0.04	N/A

Table 4: Stratification of Diagnostic Accuracy of Ultrasound for Ectopic Pregnancy by Gestational Age and BMI

Stratification	Sensitivity (%)	Specificity (%)	PPV (%)	NPV (%)
Gestational Age 6–7 weeks	98.55%	57.14%	97.19%	66.67%
Gestational Age >7 weeks	96.36%	66.67%	97.59%	57.14%
BMI 25–26 kg/m²	98.53%	66.67%	97.85%	75.00%
BMI >26 kg/m²	96.43%	50.00%	96.43%	46.15%

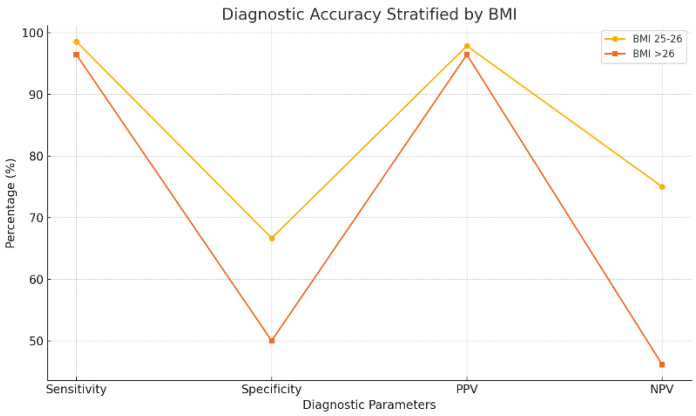

Figure 1 Diagnostic Accuracy Stratified by BMI

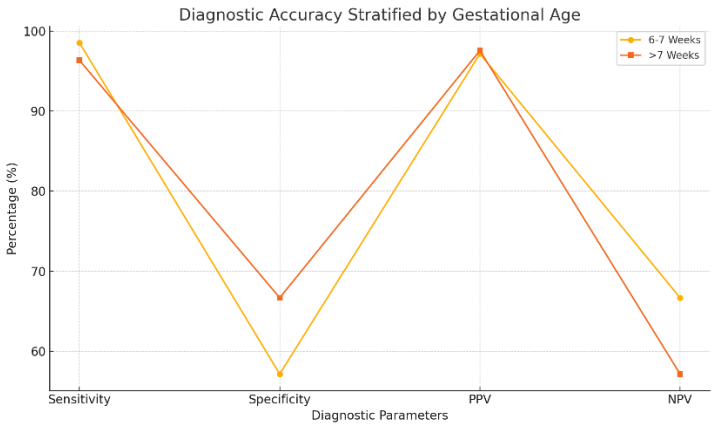

Figure 2 Diagnostic Accuracy Stratified by Gestational Age

DISCUSSION

Ectopic pregnancy remains a significant contributor to maternal morbidity and mortality, emphasizing the critical need for early and accurate diagnosis to prevent life-threatening complications (12,13). The present study aimed to evaluate the diagnostic performance of ultrasound, particularly transvaginal ultrasonography, using surgical findings as the gold standard. The results demonstrated high diagnostic efficacy, with a sensitivity of 97.77%, a specificity of 60.0%, a diagnostic accuracy of 95.42%, a positive predictive value (PPV) of 97.35%, and a negative predictive value (NPV) of 64.29%. The positive likelihood ratio (LR+) of 2.44 and a negative likelihood ratio (LR-) of 0.04 further reinforced the strength of ultrasound as a frontline diagnostic modality, particularly in identifying ectopic pregnancies at an early stage. Comparison with previous literature reveals congruence in diagnostic sensitivity, albeit with varying specificity. A previous study reported a sensitivity of 99.52%, specificity of 11.11%, and diagnostic accuracy of 95.83%, closely aligning with the sensitivity and overall accuracy found in the current investigation (14,15). However, the specificity in the present study was notably higher, indicating improved capability to correctly exclude non-ectopic cases. Another investigation observed a lower sensitivity

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of 73.1%, specificity of 75%, and diagnostic accuracy of 73.3%, suggesting variability likely influenced by factors such as operator skill, imaging protocols, and gestational age at presentation (16,17). The PPV reported in earlier research (96.2%) closely paralleled the current study's PPV of 97.35%, suggesting strong consistency in predicting true positives. Moreover, the NPV in this investigation (64.29%) exceeded the 50% reported previously, indicating relatively enhanced reliability in ruling out ectopic pregnancies when the ultrasound is negative (18).

Additional findings from other studies demonstrated a high sensitivity, reaching 100% in some instances, which supports the notion that surgical findings remain the definitive diagnostic standard. Another investigation showed 96.7% positive ultrasound evaluations and a 100% sensitivity, comparable to the 97.77% sensitivity noted in the present study (19). These results collectively highlight the consistent diagnostic strength of ultrasound, while also bringing attention to moderate specificity and the potential for false-positive diagnoses. The principal implication of these findings is that while ultrasound reliably detects ectopic pregnancies with high sensitivity and positive predictive value, its moderate specificity necessitates caution. False-positive diagnoses, though fewer compared to earlier studies, remain a concern as they could potentially lead to unnecessary surgical interventions. This limitation underscores the importance of integrating adjunctive diagnostic strategies, such as serial β-hCG monitoring, color Doppler imaging, or alternative imaging modalities like magnetic resonance imaging (MRI), particularly in ambiguous cases (20). The strengths of this study include the use of surgical findings as a definitive gold standard, minimizing diagnostic ambiguity, and the performance of ultrasound examinations by experienced radiologists, which likely reduced operator-related variability. Additionally, a structured data collection methodology was employed, thereby enhancing the reliability of the findings. The heterogeneity of the study population further enhances the generalizability of the results across different clinical settings.

Nonetheless, the study is not without limitations. The moderate specificity indicates that false positives were not entirely eliminated, which could lead to overtreatment in some cases. The single-center nature of the research may limit the extrapolation of results to other institutions with varying levels of ultrasound expertise. Another limitation is the absence of interobserver variability assessment, an important consideration given that ultrasound interpretation can differ significantly between operators. Furthermore, complementary modalities such as Doppler ultrasound, contrast-enhanced ultrasound, or serum biomarkers like progesterone and pregnancy-associated plasma protein-A (PAPP-A) were not included, which might have further improved diagnostic precision. Future research should focus on addressing these gaps by incorporating multi-center designs, evaluating interobserver variability, and exploring the utility of advanced imaging techniques and biomarker integration to enhance specificity. The emerging application of artificial intelligence algorithms in ultrasound interpretation holds considerable promise for reducing operator dependency and improving diagnostic accuracy, especially in challenging or indeterminate cases (21). In conclusion, ultrasound remains a highly effective and accessible modality for diagnosing ectopic pregnancy, offering excellent sensitivity and positive predictive value. However, the moderate specificity observed necessitates a cautious and comprehensive diagnostic approach, incorporating clinical judgment and adjunct investigations to optimize patient outcomes and minimize unnecessary interventions. Continued refinement of ultrasound techniques and the integration of technological innovations are crucial steps towards enhancing the diagnostic landscape for ectopic pregnancy.

CONCLUSION

This study highlights the crucial role of ultrasound as a highly reliable and practical tool for the diagnosis of ectopic pregnancy, demonstrating strong alignment with surgical findings. While ultrasound offers remarkable accuracy and sensitivity, the moderate specificity observed suggests the importance of incorporating additional confirmatory strategies in selected cases to avoid unnecessary interventions. As an accessible, non-invasive imaging modality, ultrasound remains indispensable in early pregnancy assessment, significantly contributing to the timely management of ectopic pregnancies. The findings emphasize the ongoing need for advancements in imaging techniques to further refine diagnostic precision and enhance patient outcomes, reinforcing the value of ultrasound as a cornerstone in reproductive healthcare.

AUTHOR CONTRIBUTION

Author	Contribution
Hira jam	Substantial Contribution to study design, analysis, acquisition of Data Manuscript Writing Has given Final Approval of the version to be published
Shazia Naseeb*	Substantial Contribution to study design, acquisition and interpretation of Data Critical Review and Manuscript Writing Has given Final Approval of the version to be published
Iqra jam	Substantial Contribution to acquisition and interpretation of Data Has given Final Approval of the version to be published

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